

THE TRAVEL OF CIRCULAR DEPRESSIONS AND TORNADOES AND THE RELATION OF PRESSURE TO WIND FOR CIRCULAR ISOBARS.

By Sir NAPIER SHAW.

This memoir is a continuation of the study of traveling cyclonic depressions which was begun in the *Life History of Surface Air Currents* (M. O. 174), published in 1906. Those who are accustomed to study weather maps have generally formed the idea that the typical cyclonic depression which is represented by a group of concentric circular isobars on the map is the base of a column of air whirling about an axis and traveling over the country. Without any special examination of the question the foot of the axis of the whirl has been supposed to be the center of the circle of isobars, and the moving column has been supposed to be fed on all sides by air moving along spiral curves to the axis. These views as applied to traveling depressions, are really erroneous.

It was shown in the *Life History* that in actual cases the air was fed into the cyclone on the right front, and, as a rule, in spite of appearance, did not reach the axis in the end, but was thrown out again from the rear of the cyclone on the same side, so that the apparent inward spiral movement was in those cases simply deceptive.

The new investigation began by pointing out that there might be cases of revolving columns of air traveling over the country, the bases of which were not represented on the map by groups of circular isobars, but by the isobars of "a small secondary." The destructive small secondary of March 24, 1895, was identified as an example. The tornado in South Wales on October 27, 1913, was cited as another example, and it was generally concluded that traveling revolving columns of air were to be found as secondaries mainly in the southern parts of great cyclonic depressions, not at the centers of those depressions. The primary depression was thought to represent motion of a different kind. These conclusions were set out in a paper on *Revolving Fluid in the Atmosphere* before the Royal Society in June, 1917.

The present memoir recapitulates that paper and carries the study further by calling attention to certain propositions applicable to the case of what is called the "normal cyclone"; that is, one in which the velocity in rotation is proportional to the distance from the axis as it is in the case of a revolving solid. This normal cyclone is supposed to travel with a specified velocity which is provided for by the proper adjustment of the distribution of pressure.

It is explained that what may be called the center of winds, or the "kinematic center" of the motion; that is, the point round which the winds of a map would appear to circulate, is not the center of isobars, but a point some way from that center on the left of its line of motion. The paths of air would be those traced out by points attached to a horizontal circle, which has its center at the true center of permanent rotation (called the tornado center), and which rolls along the path of the kinematic center. The distance apart of the real center of rotation and the apparent or instantaneous center depends on the rate of rotation and the rate of travel: it may be in some cases 60 miles or more.

The center of isobars lies between the other two centers at a position which can also be calculated from the rate of rotation and the rate of travel by allowing for the distribution of pressure corresponding to each. The whole field of pressure will consist of the combination of the circular isobars representing the rotation, with the linear

isobars representing a stream of air which would carry the rotating column along. The complete base of the revolving column will include any circular isobars shown on the map on the left-hand side of the path of the center, and a number of additional isobars formed of arcs of circles on the right hand side of the path of the center of the disk or circular base which fill up the area of the disk. Thus a spinning disk of air in a flowing stream of air would give to a map the appearance of winds circulating round a point on the left of its path, and the controlling pressure which would keep the system in being is a set of isobars centered round a different point the actual center of isobars on the map, also on the left. The position of the actual center of the disk itself would not attract attention at all. It would be somewhere in a set of curved isobars; and though its position could be ascertained if the rate of travel were known, there is nothing special to mark it on the map.

It is on that account that the true position of the axis of rotation has never been suspected during the 60 years of the study of weather maps, yet the true position is a matter of great importance for the physics and dynamics of traveling cyclones. The physical processes of ascending air, rainfall, and the like should be thought of as referred to the center of the traveling disk, not to the point on the map which for the moment has no velocity; nor to the still more apparent center of isobars.

It is also shown that air in instantaneous rotation round a point will develop a similar circulation at successive points along a line on the map if it is pushed by a uniform field of pressure toward the right of the path which the center has to follow, and this may prove to be the operative cause of the travel of isobars in certain cases. Any group of isobars which (apart from disturbance at the surface) are not in agreement with the actual winds are in a condition to travel like a cyclone, the direction and speed of travel depending upon the divergence between the actual winds and the winds computed from the isobars.—*Meteorological Office Circular 25, June 24, 1918.*

THE RELATION OF WIND TO THE DISTRIBUTION OF BAROMETRIC PRESSURE. (MANUAL OF METEOROLOGY, PART IV.)

By Sir NAPIER SHAW.

Sir Napier Shaw's recently published work, on "the Relation of the Wind to the Distribution of Barometric Pressure," which comprises Part IV of a "Manual of Meteorology," is largely a summary of previous efforts and investigations in aerology.² In the preface, the author says: "It represents the progress made chiefly by those who have been associated in the work of the Meteorological Office in the past 20 years. * * * Our concern in this work is to present a summary * * * in the most handy form for conveying an idea of the information which is available."

The subject matter of the book proceeds logically from the observation of surface phenomena to those of the upper air, in order to establish, if possible, some relation between these surface phenomena and the processes which are taking place aloft. Particular emphasis is

¹ *Geophysical Memoirs*, No. 12, British Meteorological Office, 1918, 4°, 44 pp., 5 pl., 2 figs.

² Cambridge, 1919, 4°, 160 pp., 4 pl.

³ A review of this work by Gordon Dobson is published in the *Quart. Jour. Roy. Meteorological Soc.*, July, 1919, vol. 45, pp. 262-264.